How will the radiation of outer space affect the ability of rennet enzyme to curdle milk when traveling to Mars?

Kecia Goodman[1], Dan Andrews[1], Dr. Lester Wilson[2]
[1]Ames CSD, [2]Iowa State University

Health Benefits of Cheese and the Mars Mission

Cheese has many nutritional benefits. It is a great source of high quality protein, calcium, phosphorus, zinc, vitamin A, riboflavin and vitamin B12.

The Mars Mission will eventually include sending astronauts to Mars. These astronauts will be in space for extended periods of time and will need adequate nutrition from sources that are light weight and do not take up much space. Low Heat, Nonfat Dry Milk (NFDM) and dry Rennet Enzyme are light weight and do not take up much space, but still have the essential nutrients the astronauts will need on this long mission. Using water, dry milk and rennet the astronauts will have the ingredients necessary to make cheese in space and on Mars.

Why use Rennet?

The only step absolutely necessary for the production of cheese is the separation of the milk into solid curds and liquid whey. This is usually done by souring the milk and adding rennet. Rennet is an enzyme that sets cheese into a strong and rubbery gel in low-acidity environments that are suitable for bacteria cultures which flavor the cheese.

How is radiation involved?

Radiation levels in space have been measured to between 1Gy and 5Gy during a Mars mission. These levels of radiation can cause a lot of damage to people, but not to microorganisms. As radiation travels through materials in space some of the radiant energy is absorbed by the material. The material will receive different levels of damage depending on the amount of radiant energy absorbed by the material. Our research looks at how radiation will affect the rennet's ability to curdle milk.

HYPOTHESIS

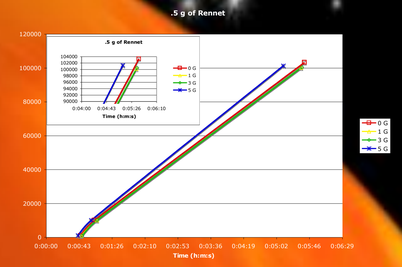
If rennet receives 5Gy of gamma radiation during the Mars mission, then the rennet will have lost some of the rennet's ability to produce cheese, because the rennet has been degraded through the radiation process.

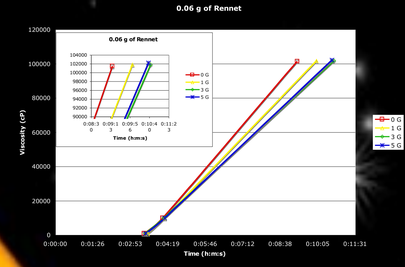
PROCEDURE

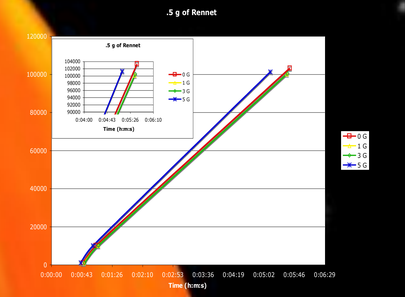
1. Gamma radiate rennet (CHY-MAX Powder Extra NB\0.5 kg) to levels of 0, 1, 3 and 5 Gray
2. Measure 0.04 g, 0.06 g, 0.2 g and 0.5 g for each radiated treatment of rennet (0 Gy, 1 Gy, 3 Gy and 5 Gy) times 3 trials of each into dark vial bottles with screw top lids
3. Warm water bath to 33°C (enzyme optimum for cheddar cheese manufacture)
4. Rehydrate the low heat treated NFDM milk
   - Measure 890 mL of distilled water
   - Add 1 1/3 cups low heat, nonfat dry milk
   - Mix vigorously
5. Measure out 300 mL of milk into large test tube
6. Put milk in the 33°C water bath for a minimum of 20 minutes to acclimatize to this temperature
7. Turn on viscometer and auto zero machine.
5. Turn on video camera

*The remaining steps need to be done accurately and in 40 seconds or less or data will be missed.

9. Measure 10 mL of distilled water into a 40 mL beaker
10. With pipette, remove about 2 mL of the distilled water from the 10 mL sample for rinsing the vial bottle.
11. Add sample of rennet to the beaker
12. Pipette the 2 mL portion of water into the vial bottle & dissolve remaining residue
13. Pour the 2 mL sample with dissolved residue into the 40 mL beaker and mix well until all rennet is dissolved
14. Pour 10 mL rennet solution into milk and start timer
15. Thoroughly mix milk and rennet throughout the length of the test tube for 10 seconds.
16. Attach T-bar (size c)
17. Position test tube directly under viscometer so T-bar does not strike the walls of the test tube
18. Set rpm to 5.0 and select display to show cP
19. Add thermometer to test tube and start vertical motor (heliopath)
20. When 100,000 cP is reached, allow the vertical motor to continue cycle until it reaches the top. Then shut down the system and camera
21. Record viscosity at 1,000, 10,000, and 100,000 cP







RESULTS

Statistical analysis of the data still needs to be done.

Preliminary analysis indicates that there may be a correlation between the amount of radiation that the rennet is exposed to on a Mars mission and the amount of time that it takes for the milk to curdle. In looking at the graphs above, rennet radiated at 0 Gy usually curdles milk at a faster rate than that of the radiated samples. This is not as significant as was expected, and it could be within the margins of experimental and/or statistical error.

Work is continuing to refine the effects of radiation on rennet and the curdling of milk.

ACKNOWLEDGEMENTS

I would like to thank the U.S. DOE Office of Science for funding the ACTS program and Ames Laboratory for hosting the ACTS program. I would also like to thank my mentor Dr. Lester Wilson, University Professor Iowa State University Food Science and Human Nutrition Department and Dillan Drury, Undergraduate Student Iowa State University Food Science and Human Nutrition Department. Thank you to Dr. Fred A. Payne, Professor of Food Engineering University of Kentucky, Dr. Graciela Wild Padua, Department of Food Science and Human Nutrition University of Illinois, Dr. Michele Perchonok, Shuttle Food System Manager and Advanced Food Technology Manager NASA/JSC and Karla Albert, Senior Scientist Chr. Hansen Inc. A special thanks to Dr. Adah Leshem-Ackerman, Lynne Bleeker, Jessica Gogerty and Karen Wignall for all of their support throughout the program.